AMENDMENTS TO THE CLAIMS

1. (Original) A magnetic sensor comprising:

a substrate;

at least one magnetoresistive element formed on the substrate; and

at least one pair of permanent magnet films that are connected to both ends of the magnetoresistive element, so that a magnitude of an external magnetic field is detected based on a magnetoresistive effect of the magnetoresistive element,

wherein a magnetization direction of a pinned layer of the magnetoresistive element forms a prescribed angle of 45° relative to a longitudinal direction of the magnetoresistive element.

2. (Original) A magnetic sensor comprising:

a substrate;

at least one magnetoresistive element formed on the substrate; and

at least one pair of permanent magnet films that are connected to both ends of the magnetoresistive element, so that a magnitude of an external magnetic field is detected based on a magnetoresistive effect of the magnetoresistive element,

wherein a magnetization direction of a pinned layer of the magnetoresistive element forms a prescribed angle of 45° relative to a direction of magnetizing the permanent magnet film.

3. (Original) A magnetic sensor according to claim 1, wherein the magnetization direction of the pinned layer, which is pinned by a pinning layer upon an ordering heat treatment of the magnetoresistive element, is substantially identical to a magnetization direction of the permanent magnet film after being magnetized.

4. (Original) A magnetic sensor according to claim 2, wherein the magnetization direction of the pinned layer, which is pinned by a pinning layer upon an ordering heat treatment of the magnetoresistive element, is substantially identical to a magnetization direction of the permanent magnet film after being magnetized.

5. (Original) A magnetic sensor according to claim 1 or 3, wherein a magnetization direction of the permanent magnet film after being magnetized is substantially identical to a longitudinal direction of a free layer of the magnetoresistive element.

6. (Original) A magnetic sensor according to claim 2 or 4, wherein a magnetization direction of the permanent magnet film after being magnetized is substantially identical to a longitudinal direction of a free layer of the magnetoresistive element.

7. (Withdrawn) A magnetic sensor comprising:

a quartz substrate having a roughly square shape;

a first X-axis GMR element that is arranged in proximity to a first side of the quartz substrate perpendicular to an X-axis and is inclined by a prescribed angle relative to the first side;

a second X-axis GMR element that is arranged in proximity to a second side of the quartz substrate, which is opposite to the first side and is perpendicular to the X-axis, and is inclined by the prescribed angle relative to the second side;

a first Y-axis GMR element that is arranged in proximity to a third side of the quartz substrate perpendicular to a Y-axis and is inclined by the prescribed angle relative to the third side;

a second Y-axis GMR element that is arranged in proximity to a fourth side of the quartz substrate, which is opposite to the third side and is perpendicular to the Y-axis, and is inclined by the prescribed angle relative to the fourth side;

a first pair of permanent magnet films that are connected to both ends of the first X-axis GMR element and are longitudinally aligned in parallel with the first side of the quartz substrate;

a second pair of permanent magnet films that are connected to both ends of the second X-axis GMR element and are longitudinally aligned in parallel with the second side of the quartz substrate;

a third pair of permanent magnet films that are connected to both ends of the first Y-axis GMR element and are longitudinally aligned in parallel with the third side of the quartz substrate; and

a fourth pair of permanent magnet films that are connected to both ends of the second Y-axis GMR element and are longitudinally aligned in parallel with the fourth side of the quartz substrate.

8. (Withdrawn) A magnetic sensor according to claim 7, wherein the prescribed angle is set to 45°.

9. (Withdrawn) A magnetic sensor comprising:

a quartz substrate having a roughly square shape;

a first X-axis GMR element that is arranged in proximity to and in parallel with a first side of the quartz substrate perpendicular to an X-axis;

a second X-axis GMR element that is arranged in proximity to and in parallel with a second side of the quarts substrate, which is opposite to the first side and is perpendicular to the X-axis;

a first Y-axis GMR element that is arranged in proximity to and in parallel with a third side of the quartz substrate perpendicular to a Y-axis;

a second Y-axis GMR element that is arranged in proximity to and in parallel with a fourth side of the quartz substrate, which is opposite to the third side and is perpendicular to the Y-axis;

a first pair of permanent magnet films that are connected to both ends of the first X-axis GMR element and are longitudinally aligned in parallel with the first side of the quartz substrate;

a second pair of permanent magnet films that are connected to both ends of the second X-axis GMR element and are longitudinally aligned in parallel with the second side of the quartz substrate;

a third pair of permanent magnet films that are connected to both ends of the first Y-axis GMR element and are longitudinally aligned in parallel with the third side of the quartz substrate; and

a fourth pair of permanent magnet films that are connected to both ends of the second Y-axis GMR element and are longitudinally aligned in parallel with the fourth side of the quartz substrate.

10. (Withdrawn) A magnetic sensor comprising:

a quartz substrate having a roughly square shape;

an X-axis GMR element that is arranged in proximity to and in parallel with a first side of the quartz substrate perpendicular to an X-axis;

a Y-axis GMR element that is arranged in proximity to and in parallel with a second side of the quartz substrate perpendicular to a Y-axis;

a first pair of permanent magnet films that are connected to both ends of the X-axis GMR element and are arranged in parallel with the first side of the quartz substrate; and

a second pair of permanent magnet films that are connected to both ends of the Y-axis GMR element and are arranged in parallel with the second side of the quartz substrate.

11. (Withdrawn) A magnetic sensor according to claim 7, wherein the permanent magnet films are magnetized using at least four permanent magnets, which are arranged in conformity with four corners of the quartz substrate in such a way that adjoining permanent magnets differ from each other in polarity.

12. (Withdrawn) A magnetic sensor according to claim 9, wherein the permanent magnet films are magnetized using at least three permanent magnets, which are on a diagonal line and two opposite corners of the quartz substrate in such a way that adjoining permanent magnets differ from each other in polarity.

13. (Withdrawn) A magnetic sensor according to claim 9, wherein the permanent magnet films are magnetized using at least three permanent magnets of the same polarity, in which one permanent magnet is arranged on a diagonal line of the quartz substrate and the other two permanent magnets are respectively distanced from opposite two corners of the quartz substrate, so that a distance between adjacent permanent magnets is set to be identical to a length of the diagonal line of the quartz substrate.

14. (Withdrawn) A magnetic sensor according to claim 10, wherein the permanent magnet films are magnetized by a magnetic field effected in a direction along a diagonal line of the quartz substrate.

15. (Withdrawn) A manufacturing method of a magnetic sensor, comprising the steps of:

forming a plurality of permanent magnet films on a substrate;

forming a plurality of spin valve films each composed of a pinning layer, a pinned layer, and a free layer;

subjecting the pinning layer to an ordering heat treatment;

patterning the plurality of spin valve layers to form a plurality of magnetoresistive elements, which are arranged in such a way that the plurality of permanent magnet films are paired and are respectively connected to both ends of the magnetoresistive elements; and

magnetizing the plurality of permanent magnet films,

wherein the ordering heat treatment is performed using a magnet array in which a plurality of permanent magnets are respectively arranged in conformity with four corners of a cell of the substrate such that adjoining permanent magnets differ from each other in polarity, and then the substrate is heated, and

wherein the plurality of permanent magnet films are magnetized by arranging the substrate on the magnet array without changing a relative positional relationship therebetween.

16. (Withdrawn) A manufacturing method of a magnetic sensor, comprising the steps of:

forming a plurality of permanent magnet films on a substrate;

forming a plurality of spin valve films each composed of a pinning layer, a pinned layer, and a free layer;

subjecting the pinning layer to an ordering heat treatment;

patterning the plurality of spin valve layers to form a plurality of magnetoresistive elements, which are arranged in such a way that the plurality of permanent magnet films are paired and are respectively connected to both ends of the magnetoresistive elements; and

magnetizing the plurality of permanent magnet films,

wherein the ordering heat treatment is performed by arranging the substrate in such a way that a magnetization direction therefor substantially matches a diagonal line of a cell of the substrate, which is then heated, and wherein the plurality of permanent magnet films are magnetized by arranging the substrate on a magnet array in which a plurality of permanent magnets are arranged such that adjoining permanent magnets differ from each other in polarity.

17. (Withdrawn) A manufacturing method of a magnetic sensor, comprising the steps of:

forming a plurality of permanent magnet films on a substrate;

forming a plurality of spin valve films each composed of a pinning layer, a pinned layer, and a free layer;

subjecting the pinning layer to an ordering heat treatment;

patterning the plurality of spin valve layers to form a plurality of magnetoresistive elements, which are arranged in such a way that the plurality of permanent magnet films are paired and are respectively connected to both ends of the magnetoresistive elements; and

magnetizing the plurality of permanent magnet films,

wherein the ordering heat treatment is performed by arranging the substrate in such a way that a magnetization direction therefor substantially matches a diagonal line of a cell of the substrate, which is then heated, and

wherein the plurality of permanent magnet films are magnetized by arranging the substrate in such a way that the magnetization direction therefor substantially matches the diagonal line of the cell of the substrate.

18. (New) A magnetic sensor comprising:

a substrate:

at least one magnetoresistive element formed on the substrate; and

at least one pair of permanent magnet films that are connected to both ends of the magnetoresistive element, so that a magnitude of an external magnetic field is detected based on a magnetoresistive effect of the magnetoresistive element, wherein a magnetization direction of a pinned layer of the magnetoresistive element forms a prescribed angle relative to a longitudinal direction of the magnetoresistive element.